Water Resources Management

إدارة مصادر المياه

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CH.1 Introduction

→ Hydrologic Budget = Water Budget = Water Balance

⇒ Surface Water System Hydrologic Budget

$$P + Q_{in} - Q_{out} + Q_g - E_s - T_s - I = \Delta S$$

$$P + \Delta Q + Q_g - E_s - T_s - I = \Delta S_s$$

⇒ Groundwater System Hydrologic Budget

$$I + \underbrace{G_{in} - G_{out}}_{\Delta G} - Q_g - E_g - T_g = \Delta S_g$$

⇒ System Hydrologic Budget

$$P + \Delta Q + \Delta G - E - T = \Delta S$$

Where:

→ P: Precipitation

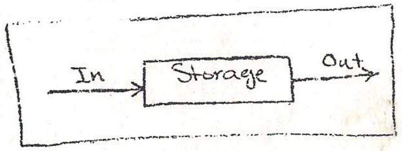
→ ΔQ: Surface water flow = $Q_{in} - Q_{out}$ (Q_{in} ↓ into the system; Q_{out} ↓ out of the system)

→ ΔG: Groundwater flow = $G_{in} - G_{out}$ (G_{in} ↓ into the system; G_{out} ↓ out of the system)

→ E: Evaporation

→ T: Transpiration

→ ΔS: Change in Storage



⇔ **In − Out = Change in Storage**

2.2.3

Given: Sieving Analysis

Reqd.: Prepare a grain size distribution curve for this sample.

Sieve #	Grain Size (mm)	Mass Retained (g)	Comulative Mass Retained (g)	Passing "Finer"	% Passing "Finer"
4	4.75	11.92	11.92	438.08	97.35
8	2.36	2.66	14.58	435.42	96.76
16	1.18	37.30	51.88	398.12	88.47
20	0.84	87.53	139.41	310.59	69.02
25	0.71	78.07	217.48	232.52	51.67
30	0.6	72.95	290.43	159.57	35.46
40	0.425	98.82	389.25	60.75	13.5
100	0.15	50.85	440.1	9.9	2.2
200	0.075	8.10	448.2	1.8	0.4
Pan	<0.075	1.8	450	0	0
Σ		450			

⇒ Passing (Finer) @ each sieve size (mm) = weight of the sample − Comulative Mass Retained

→ for example sieve 4.75mm

⇒ Passing = 450 − 11.92 = 438.08 g

⇒ % Finer (Passing) = $\frac{\text{Passing}}{\text{Weight of the sample}} * 100\%$

→ for example sieve 4.75mm

⇒ % Finer = $\frac{438.08}{450} * 100\% = 97.35\%$

1.6.2

Given:

$\Delta S = -28,900 \ m^3$

$P = 7,000 \ m^3$

$E = 7,400 \ m^3$

Reqd.: $G = ??$

Soln.:

$$P + \Delta Q + \Delta G - E - T = \Delta S$$

$$\Rightarrow G = \Delta S - P + E$$

$$\Rightarrow G = -28,900 - 7,000 + 7,400$$

$$\Rightarrow \boxed{G = -28,500}$$ #

Problems:

1.6.1 Using the data in Table 1.6.1

Net groundwater for December 1989 = ??

Given:

$\Delta S = 1,000 \ m^3$

$P = 13,500 \ m^3$

$E = 7,900 \ m^3$

Required: $G = ??$

Soln.:

$$P + \Delta Q + \Delta G - E - T = \Delta S$$

$$\Rightarrow G = \Delta S - P + E$$

$$\Rightarrow G = 1,000 - 13,500 + 7,900$$

$$\Rightarrow \boxed{G = -4,600 \ m^3}$$ #

2.5.1

→ Water level rise = ??

→ unconfined aquifer

→ precipitation = 4 inches = $\frac{4 * 2.54}{100}$ = 0.1016 m

→ porosity = 20% , specific retention = 9 %

Soln. :)

$\alpha = S_y + S_r \Rightarrow S_y = \alpha - S_r$

$\Leftrightarrow S_y = 0.2 - 0.09 \Rightarrow S_y = 0.11$

⇔ Volume of water = P * A (P ↓ precipitation)

⇒ Volume of water = 0.1016 * A

⇔ Total volume = Δh * A (Δh ↓ water level rise)

$$\Rightarrow S_y = \frac{\text{Volume of water}}{\text{Total Volume}}$$

$$\Rightarrow 0.11 = \frac{0.1016 * A}{\Delta h * A}$$

$$\Rightarrow \Delta h = \frac{0.1016}{0.11} \Rightarrow \Delta h = 0.92 \text{ m}$$

⇒ **Another Soln. :)**

$$\text{Rise} = \frac{\text{infiltration}}{\text{specific yield (fraction)}}$$

$$\Rightarrow \text{Rise} = \frac{0.1016}{0.11} = 0.92 \text{ m}$$

Specific Storage: (S_s) The amount of water that a portion of an aquifer releases from storage, per unit volume of aquifer, per unit change in hydraulic head

Storage Coefficient (Storativity): (S)

Volume of water released from storage, per unit decline of hydraulic head, per unit area of aquifer.

$$S = \frac{\text{Volume}}{\text{Area} * \text{Length}} = \frac{m^3}{m^2 * m}$$

= dimensionless ليس لها وحدة

$$S_s = \frac{\text{Volume}}{\text{Volume} * \text{Length}} = \frac{m^3}{m^3 * m} = \boxed{m^{-1}}$$

$\Rightarrow S = S_s * b$

b: aquifer thickness

2.5.3

→ How much water can be produced "Volume of Water" = ??

→ lowering the water table 7 ft

$= \frac{7*12*2.54}{100} = 2.1336\ m$

→ Area = 1 mile^2 = $1*(1609.34)^2 = 2,589,975.24\ m^2$

→ porosity (α) = 0.38

→ specific retention = 0.15

Soln.:

⇒ Specific yield = ??

$\alpha = S_y + S_r$

$\Rightarrow S_y = \alpha - S_r$

$= 0.38 - 0.15 \Rightarrow \boxed{S_y = 0.23}$

⇒ Specific yield = $\frac{\text{Volume of water drained by gravity}}{\text{Total Volume}}$

$\Rightarrow 0.23 = \frac{\text{Volume of water}}{\Delta h * A}$

⇒ volume of water = $0.23 * 2.1336 * 2,589,975.24$

$= 1270,973.37\ m^3$

2.5.2

→ leakage → low = 0.5 ft/day = $\frac{0.5*12*2.54}{100} = 0.1524\ m$
→ high = 3 ft/day = 0.9144 m

→ Area = 222 acres

→ S_y = 20 %

→ Average regional groundwater level rise = ??

if: the effect of leakage :-

(a) 222 acres. 1 acre = 4,046.86 m^2

⇒ low :- $S_y = \frac{W_w}{V_T} = \frac{\text{leakage} * \text{Area (lake)}}{\text{Groundwater level Rise} * \text{Area (Effect)}}$

⇒ low ⇒ $0.2 = \frac{0.1524 * 222 * 4,046.86}{h * 222 * 4,046.86}$

$\Rightarrow h = \frac{0.1524}{0.2} = 0.762$ m/day

⇒ high ⇒ $0.2 = \frac{0.9144}{h} \Rightarrow h = \frac{0.9144}{0.2} \Rightarrow h = 4.572$ m/day

⇒ Average = $\frac{0.762 + 4.572}{2} = 2.667$ m

(b) low ⇒ h = ?? , Area Effect = 1 mile^2.

$0.2 = \frac{0.1524 * 222 * 4,046.86}{h * 1 * (1609.34)^2}$

⇒ h = 0.264 m

high ⇒ h = 1.586 m

⇒ Average = 0.925 m

(c) 5 mile^2 ⇒ Average = 0.185 m

(d) 25 mile^2 ⇒ Average = 0.0368 m

Vertical Distribution of Groundwater:-

① Zone of Aeration
  ⓐ Capillary Zone
  ⓑ immediate vadose zone
  ⓒ Soil-water zone
② Zone of Saturation

⇒ Specific Retention: Is the ratio of the volume of water it will retain after saturation against the force of gravity to its own volume.

$$S_r = \frac{W_r}{V_t}$$

⇒ Specific yield. Is the ratio of the volume of water, after saturation, can be drained by gravity to its own volume

$$S_y = \frac{W_y}{V_t} = \frac{\text{Volume of water drained}}{\text{Total Rock or material volume}}$$

$$\alpha = S_r + S_y$$

$$\text{Rise in Water Table} = \frac{\text{Infiltration}}{\text{Specific yield (fraction)}}$$

2.8.2 Specific Storage $= 3 * 10^{-5}\ m^{-1}$

confined aquifer thickness = 45 m

How much water would the aquifer produce = ??

piezometric level lowered 10 m

Area = 1 Km^2.

Soln.:) → Storage Coefficient = Specific Storage * aquifer thickness

⇒ $S = S_s * b$

⇒ $S = 3 * 10^{-5} * 45$ ⇒ $S = 1.35 * 10^{-3}$

→ Storage Coefficient = $\frac{\text{Volume of water}}{\text{Area * piezometric head}}$

⇒ Volume of water = $1.35 * 10^{-3} * (1*10^3)^2 * 10$

$= 13{,}500\ m^3$

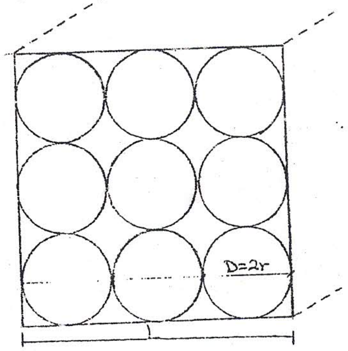
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Problems:

2.2.1

Given:
→ Cubical pattern
→ grain size uniform
→ each sphere touches all neighboring spheres.

Reqd.:
→ Porosity of a sample = ??
→ Does the porosity depend on the grain size?



Soln.:

→ $\alpha = \frac{V_v}{V_T} = \frac{V_T - V_s}{V_T}$

→ $V_T = ??$

Cube with Length = L

⇒ $V_T = L^3$

$L = n * D = n * 2r$

⇒ $V_T = 8n^3r^3$ ((n: عدد الحبيبات في وحدة الطول))

$V_s = ??$

⇒ for one particle

$V_s = \frac{4}{3}\pi r^3$

⇒ for all particles

⇒ $V_s = n * n * n * \frac{4}{3}\pi r^3$

$V_s = n^3 * \frac{4}{3}\pi r^3$

$$\Rightarrow \alpha = \frac{8n^3r^3 - \frac{4}{3}\pi n^3 r^3}{8n^3r^3} = \frac{n^3r^3(8 - \frac{4}{3}\pi)}{8n^3r^3}$$

$$\Rightarrow \alpha = \frac{8 - \frac{4}{3}\pi}{8} = 1 - \frac{4}{24}\pi = 0.476 = 47.6\%$$ #

that means the porosity does not depending on grain size.

CH.2 Occurrence of Groundwater

2.2.2 Porosity المسامية

$\alpha = \frac{V_v}{V_T}$

2.2.3 Soil Classification

Uniformity Coefficient ((Uc))

$U_c = \frac{D_{60}}{D_{10}}$

$= \frac{\text{قطر فتحة المنخل عندما يكون نسبة المار } \%60}{\text{قطر فتحة المنخل عندما يكون نسبة المار } \%10}$

⇒ Sieve Analysis

منحنى يوضح العلاقة بين grain size (mm) و نسبة المار (%)

grain size (mm) ↓ x-axis ⇒ Log scale

نسبة المار (%) ↓ y-axis